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EXAMINER

KIELIN, ERIK J

ART UNIT	PAPER NUMBER
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2813

DATE MAILED: 02/04/2003

34

Please find below and/or attached an Office communication concerning this application or proceeding.

# Office Action Summary

Application No.

09/296,835

Applicant(s)

WEIMER ET AL.

Examiner

Erik Kielin

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

## Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

## Status

- 1) ☒ Responsive to communication(s) filed on 12 November 2002.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

## Disposition of Claims

- 4) ☒ Claim(s) 2-5, 8, 10-12 and 42-47 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 2-5, 8, 10-12 and 42-47 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

## Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on \_\_\_\_\_ is: a) ☐ approved b) ☐ disapproved by the Examiner.
- If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

## Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

## Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) \_\_\_\_\_
- 4) ☐ Interview Summary (PTO-413) Paper No(s). \_\_\_\_\_
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: \_\_\_\_\_

### DETAILED ACTION

This action responds to the amendment filed 12 November 2003 (Paper No. 32).

#### *Claim Rejections - 35 USC § 103*

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. Claims 8, 2-5, 10-12, **45**, **46**, and **47** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Patel et al.** (US 5,374,578) in view of either of **Emesh et al.** (US 5,728,603) and **Chivukula et al.** (US 6,066,581), and further in view of the excerpt from the basic textbook of **Van Zant**, (Microchip Fabrication, A Practical Guide to Semiconductor Processing, 3rd ed. McGraw-Hill: New York, 1997, pp. 157-160) and considered with the CRC Handbook of Chemistry and Physics 63<sup>rd</sup> Edition, CRC Press: Boca Raton FL, pp. D-196 to D-197 (used for a showing of inherency only).

Regarding independent claims 8, 45, 46, and 47, **Patel** discloses a method of forming a semiconductor device comprising,

forming an oxygen deficient dielectric (called "ferroelectric") film **14** (Figs. 2-6) such as PZT which inherently has a dielectric constant of greater than 25 (see **Emesh** col. 8, Table 1 who teaches the dielectric of PZT the same ferroelectric in **Patel**);

subjecting the dielectric film to an oxidation in "[g]ases like oxygen, ozone or air" (column 4, lines 10-11) using RTA (rapid thermal annealing), which must necessarily occur,

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then, in an RTA chamber --as further limited by instant claim 12-- at a temperature range of 650-850 °C for about 5-30 seconds (as further limited by instant claims 2-4) in order to increase the oxygen content of the ferroelectric film (column 2, lines 30-33); and

performing a stabilizing treatment using oxygen anneal either before or after the ozone anneal (column 4, lines 23-29) --as further limited by instant claim 10.

**Patel** does not teach using wet oxidation to anneal the ferroelectric PZT layer **14**.

**Emesh** teaches forming an oxygen deficient ferroelectric material such as PZT; subjecting the dielectric film to a wet oxidation using a mixture comprising water and ozone in a rapid thermal annealing (RTA) chamber in order to reduce the temperature at which the ferroelectric material densifies/crystallizes and also to reduce the stress in the ferroelectric film and improves its the electrical properties (column 5, lines 50-67) which also inherently increases the oxygen content of the film as indicated by reduced leakage current (sentence bridging columns 3-4).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate water during the ozone anneal of **Patel** for the reasons indicated in **Emesh** which includes at least reducing the stress in the ferroelectric film and improving the electrical properties such as increased dielectric constant (column 5, lines 50-67; col. 8, Table 1).

Similarly, **Chivukula** teaches forming an oxygen deficient ferroelectric material such as PZT; subjecting the dielectric film to a wet oxidation using a mixture comprising water and ozone at a temperature of 450-650 °C in a rapid thermal annealing (RTA) chamber for 30 seconds to several minutes to form uniform grain sizes in the ferroelectric material in a shorter

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time, at reduced temperature and superior characteristics during high frequency use compared to using dry oxidation (column 14, lines 27-48). (See also column 13, lines 30-53.)

It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate water during the ozone anneal of **Patel** for the reasons indicated in **Chivukula**, as noted, the amount of greater than 0.005 of steam relative to the other gases is inherently taught, as noted.

Furthermore, each of **Emesh** and **Chivukula** teaches that

“Water vapour was conveniently introduced into the annealing atmosphere of the rapid thermal anneal (RTA) system during the annealing of the PZT by passing oxygen (O<sub>2</sub>) through a double bubbler containing purified deionized water, so that the oxygen was saturated with water vapour, e.g. using a gas flow rate of about 2 L/min.” (Emesh col. 5, lines 14-28; Chivukula, col. 13, lines 40-46).

It is held absent evidence to the contrary that the steam is present in an amount greater than about 0.005 (0.5%) relative to the other gases in the chamber. Support to show inherency can be easily determined from data in the Handbook of Chemistry and Physics. Pages D-196 and D-197 of the CRC (63<sup>rd</sup> edition) provide a Table having the vapour pressure of water as a function of temperature at temperatures below 100 °C. Because each of Emesh and Chivukula teaches that the oxygen is “saturated with water” all that need be known is the temperature of the bubbler. Even if it is assumed that bubbler is as low as standard room temperature (i.e. 25 °C), the CRC table of Vapor Pressure of Water Below 100 °C, indicates that the partial pressure of water is 23.756 Torr. Since atmospheric pressure is 760 Torr, the partial pressure of water in water-saturated oxygen is  $23.756/760 \approx 0.0313$  or (3.13 %). Typically bubblers are heated indicating even high partial pressures of water. Accordingly, the water vapor is inherently greater than

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0.005 relative to the other gases based upon the teachings in each of **Emesh** and **Chivukula**.

(See MPEP 2112.)

**Patel** in view of either of **Emesh** and **Chivukula** further does not teach that the steam is provided by using a mixture of hydrogen and oxygen. Instead, each of **Emesh** and **Chivukula** use a bubbler (**Emesh** at col. 5, lines 57-59; **Chivukula** at col. 13, lines 40-46).

**Van Zant** teaches that "Dryox," a mixture of hydrogen and oxygen which react to form a steam oxidizing mixture in the reactor, is preferred over liquid systems such as a bubbler, because the process is cleaner and more controllable and also that "Dryox is the preferred method for production of advanced devices." (See pp. 157-160 -- especially page 160.)

It would have been obvious to one of ordinary skill in the art at the time the invention was made to use hydrogen and oxygen as taught by **Van Zant** to form the steam for the wet oxidation mixture of either of **Emesh** and **Chivukula**, for the reasons indicated in **Van Zant**, as noted and especially because "Dryox" is preferred to bubblers which **Emesh** and **Chivukula** use.

Furthermore, it would be a matter of design choice as to which method of introducing the water to the oxidizing atmosphere of **Patel** in view of **Emesh** and **Chivukula**, because it appears that any known method of providing steam would work just as well and because there is no evidence of record to indicate that the mixture of hydrogen and oxygen would work better than other methods. Rather, Applicant's specification teaches away from such unexpected results.

Applicant teaches,

"One of several techniques can be used to provide steam to a vicinity of the insulating film. Such techniques include using a **bubbled water vapor system**, a pyrogenic system or a catalytic system, or generating steam in the chamber *in situ*." (Emphasis added. See instant specification, page 3, lines 13-17.)

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In other words, any of the presently notoriously well-known means to form the steam, which are specifically used in the art for oxidation, could be used, according to Applicant. Also note that the paragraph bridging pages 7 and 8 of Applicant's specification indicates specifically that a bubbler can be used in the instant invention.

Then further regarding claims 8 and 47, and additionally regarding claim 5, the ratio of hydrogen to oxygen is not taught.

However, each of **Emesh** and **Chivukula** indicate that the wet oxidation is carried out in water plus oxygen and ozone (**Emesh** at col. 5, lines 19-28; **Chivukula** at col. 13, lines 36-46). "[I]n considering the disclosure of a reference, it is proper to take into account not only specific teachings of the reference but also the inferences which one skilled in the art would reasonably be expected to draw therefrom." *In re Preda*, 401 F.2d 825, 826, 159 USPQ 342, 344 (CCPA 1968) See also *In re Lamberti*, 545 F.2d 747, 750, 192 USPQ 278, 280 (CCPA 1976). With this in mind, because each of **Emesh** and **Chivukula** teach that oxygen must be in excess of the water vapor, one of ordinary skill would know, based upon the stoichiometry of the reaction between hydrogen and oxygen to form the "Dryox" mixture containing water (as taught by **Van Zant**) that the ratio of hydrogen to oxygen must necessarily be less than or equal to about 0.67 because hydrogen reacts with oxygen in a 2 to 1 stoichiometric ratio ( $2 \text{ H}_2 + \text{O}_2 \rightarrow 2 \text{ H}_2\text{O}$ ). Otherwise, the oxygen will be depleted in the formation of water and excess hydrogen would remain, contrary to the teaching in each of **Emesh** and **Chivukula**. Accordingly, one of ordinary skill would clearly recognize that using the more desirable method of "Dryox" oxidation, as taught by **Van Zant**, would necessarily require a range hydrogen to oxygen of 0.67 or less in order to achieve the mixture taught by each of **Emesh** and **Chivukula** which requires excess

oxygen with the water, which overlaps the claimed ratio of 0.1 to 0.8 (instant claim 8) and 0.1 to 0.5 (instant claim 5).

Further regarding claim 46, although a ratio of steam to the other gases is not taught to be 0.1 to 0.5 (10% to 50%) relative to the other gases, the reasoning applied above regarding the inherency of the steam being greater than 0.5% based upon the teachings of each of **Emesh** and **Chivukula**, is applied here. Additionally, although the exact range may not be indicated, these claims are *prima facie* obvious without showing that the claimed ranges achieve unexpected results relative to the prior art range. *In re Woodruff*, 16 USPQ2d 1935, 1937 (Fed. Cir. 1990). See also *In re Aller*, 105 USPQ 233 (CCPA 1955) (selection of optimum ranges within prior art general conditions is obvious). Inasmuch as the instant specification indicates that any amount of water greater than 0.5% will provide the benefit, there is presently no evidence of unexpected result for the range of 10% to 50%.

Further regarding claims 2-4, although **Patel** does not recite Applicant's exact ranges of either 450-750 °C or 750-900 °C or exact times of 20-60 seconds for the oxidation, **Patel** does disclose an overlapping temperature range of 650-850 °C and time range of 5-30 seconds, in at least one example. **Emesh** teaches 300 seconds, which is a function of the lower temperatures used. **Chivukula** teaches 30 seconds to several minutes, which are, again, temperature and material dependent. These claims are *prima facie* obvious without showing that the claimed ranges achieve unexpected results relative to the prior art range. *In re Woodruff*, 16 USPQ2d 1935, 1937 (Fed. Cir. 1990). See also *In re Aller*, 105 USPQ 233 (CCPA 1955) (selection of optimum ranges within prior art general conditions is obvious). It would have been obvious to one of ordinary skill in the art at the time the invention was made to optimize the temperature



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and anneal time to provide the best ferroelectric film, according to the precedent above. Also note, although **Emesh** teaches an ozone/water oxidizing temperature of 500 °C or less, **Emesh** also teaches that increasing the temperature at which the wet oxidation occurs increases the dielectric constant of the high dielectric constant film (column 8, lines 6-12) which is desired in the semiconductor device fabrication art especially for fabricating capacitors for DRAM devices. Accordingly, one of ordinary skill would be motivated to use higher temperatures than 500 °C, as suggested by **Emesh** to increase the dielectric constant of the ferroelectric layer to enable smaller capacitors to be formed, which in turn enables further miniaturization of semiconductor devices using capacitors.

Regarding claim 11, **Patel** does not teach performing the ozone oxidizing or the oxygen stabilizing treatments at different temperatures, but each of **Emesh** and **Chivukula** teaches that the addition of water vapor reduces the densification/crystallization temperature from dry conditions.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to perform the wet ozone anneal of **Patel** in view of **Emesh** and **Chivukula** at a lower temperature than the oxygen stabilizing anneal, because each of **Emesh** and **Chivukula** teaches a lower temperature may be used for wet versus dry oxidation, and provides examples of temperatures lower than in **Patel**.

3. Claim **42** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Patel** et al. (US 5,374,578) in view of either of **Emesh** et al. (US 5,728,603) and **Chivukula** et al. (US 6,066,581) and further in view of US 5,840,368 (**Ohmi**) and considered with the CRC Handbook

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of Chemistry and Physics 63<sup>rd</sup> Edition, CRC Press: Boca Raton FL, pp. D-196 to D-197 (used for a showing of inherency only).

The prior art of **Patel** in view of either of **Emesh** and **Chivukula** and the inherent showing from the CRC Handbook, as explained above, discloses each of the claimed features except for indicating that the steam is provided by a catalytic system.

**Ohmi** teaches a catalytic system for providing steam for wet oxidation. (paragraph bridging cols. 2-3 and col. 4, lines 40-45). **Ohmi** teaches that the catalytic oxidation beneficially reduces the temperature at which an oxidation may occur and provides a cleaner way of providing water (Abstract).

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use the catalytic method of forming steam, taught by **Ohmi**, for the wet oxidation of **Patel** in view of either of **Emesh** and **Chivukula**, for the beneficial reasons just indicated and further because, as noted above, Applicant has not indicated that there exist anything critical to the method by which the water is formed, moreover teaching away from any criticality to such method of steam production.

4. Claim **43** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Patel** et al. (US 5,374,578) in view of the excerpt from **Ghandi**, VLSI Fabrication Principles, 2<sup>nd</sup> ed. John Wiley & Sons: New York, 1994, pp. 465-466, and either of **Emesh** et al. (US 5,728,603) and **Chivukula** et al. (US 6,066,581) and considered with the CRC Handbook of Chemistry and Physics 63<sup>rd</sup> Edition, CRC Press: Boca Raton FL, pp. D-196 to D-197 (used for a showing of inherency only).

The prior art of **Patel** in view of either of **Emesh** and **Chivukula** and the inherent showing from the CRC Handbook, as explained above, discloses each of the claimed features except for indicating that the steam is provided by a pyrogenic system.

**Ghandi** teaches the benefits of using a pyrogenic system formation of steam for oxidation indicating that the method is better than a bubbler and provides better control over the partial pressure of the water and is “well suited for the manufacturing environment.” (See paragraph bridging pp. 465-466.)

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use the pyrogenic method of forming steam, taught by **Ghandi**, for the wet oxidation of **Patel** in view of either of **Emesh** and **Chivukula**, for the beneficial reasons just indicated and further because, as noted above, Applicant has not indicated that there exist anything critical to the method by which the water is formed, moreover teaching away from any criticality to such method of steam production.

5. Claim **44** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Patel** et al. (US 5,374,578) in view of either of **Emesh** et al. (US 5,728,603) and **Chivukula** et al. (US 6,066,581) and considered with the CRC Handbook of Chemistry and Physics 63<sup>rd</sup> Edition, CRC Press: Boca Raton FL, pp. D-196 to D-197 (used for a showing of inherency only).

The prior art of **Patel** in view of either of **Emesh** and **Chivukula** and the inherent showing from the CRC Handbook, as explained above, discloses each of the claimed features of claim 44. Additionally both **Emesh** and **Chivukula** teach that water is provided by a bubbler system (**Emesh** at col. 5, lines 57-59; **Chivukula** at col. 13, lines 40-46).

It would have been obvious for one of ordinary skill in the art, at the time of the invention to also use the bubbler for the wet oxidation, already indicated as obvious over either of **Emesh** and **Chivukula**, for the oxidation of Patel, because this is the manner in which **Emesh** and **Chivukula** provide water vapor and since one of ordinary skill would be motivated to use water vapor, for the reasons indicated earlier, one of ordinary skill would be especially motivated to use the system taught in **Emesh** and **Chivukula** to provide the water vapor.

#### ***Response to Arguments***

6. Applicant's arguments filed 12 November 2003 have been fully considered but they are not persuasive.

Applicant argues (at p. 6 of Paper No. 32) that the rejection of claims 8, 2-5, and 10-12 under 35 USC 103(a) over Patel in view of either of Emesh and Chivukula and further in view of Van Zant is not obvious because "Applicant's submit that there is no motivation to combine the references." In response to applicant's argument that there is no suggestion to combine the references, the examiner recognizes that obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. See *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988) and *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992). In this case, the rejection above, as repeated from the action previously filed, provides the motivation to combine the reference, stating in pertinent part,

"It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate water during the ozone

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anneal of **Patel** for the reasons indicated in **Emesh** which includes at least reducing the stress in the ferroelectric film and improving the electrical properties such as increased dielectric constant (column 5, lines 50-67; col. 8, Table 1)."

Additionally, the action states,

"**Chivukula** teaches forming an oxygen deficient ferroelectric material such as PZT; subjecting the dielectric film to a wet oxidation using a mixture comprising water and ozone at a temperature of 450-650 °C in a rapid thermal annealing (RTA) chamber for 30 seconds to several minutes to form uniform grain sizes in the ferroelectric material in a shorter time, at reduced temperature and superior characteristics during high frequency use compared to using dry oxidation (column 14, lines 27-48). (See also column 13, lines 30-53.)

It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate water during the ozone anneal of **Patel** for the reasons indicated in **Chivukula**, as noted."

Additionally the action states,

"**Van Zant** teaches that 'Dryox,' a mixture of hydrogen and oxygen which react to form a steam oxidizing mixture in the reactor, is preferred over liquid systems such as a bubbler, because the process is cleaner and more controllable and also that 'Dryox is the preferred method for production of advanced devices.' (See pp. 157-160 -- especially page 160.)

It would have been obvious to one of ordinary skill in the art at the time the invention was made to use hydrogen and oxygen as taught by **Van Zant** to form the steam for the wet oxidation mixture of either of **Emesh** and **Chivukula**, for the reasons indicated in **Van Zant**, as noted and especially because 'Dryox' is preferred to bubblers which **Emesh** and **Chivukula** use."

Accordingly, Examiner respectfully disagrees that there exists no motivation to combine the references. Rather the motivation for each is as expressly taken from the applied references. Moreover, "the strongest rationale for combining references is a recognition, expressly or impliedly in the prior art or drawn from a convincing line of reasoning based on established

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scientific principles or legal precedent, that some advantage or expected beneficial result would have been produced by their combination.” *In re Sernaker*, 702 F.2d 989, 994-95, 217 USPQ 1, 5-6 (Fed. Cir. 1983). In this case, each of the applied references of Emesh and Chivukula expressly indicates benefits of applying the wet oxidation to a ferroelectric film. According to the precedent in *In re Sernaker* this is “the strongest rationale to combine.”

In attempts to support the alleged absence of motivation to combine the applied references of Patel with Emesh, Applicant argues,

“Patel discloses that ‘oxygen anneals are done in an O<sub>2</sub> ambient at a temperature greater than 500°C . . . using a furnace anneal or rapid thermal annealing process . . . [and] [u]nfortunately, the effect of these anneals can be reduced, or even eliminated, by some of the other processing steps used to form the ferroelectric capacitor.’ (Col. 1, lines 40-47) (emphasis added). In particular, Patel suggests that ‘[o]zone anneals provide a more complete, method of supplying oxygen . . . than oxygen anneals’ (Col. 2, lines 11-13) (emphasis added). This is because ‘ozone . . . significantly decreases the number of lead (Pb) atoms lost during annealing as compared to using a conventional oxygen anneal in a furnace.’ (Col. 4, lines 18-22) (emphasis added). Accordingly, Patel uses an ambient atmosphere primarily comprising ozone. Patel also discloses that the anneal is conducted at a temperature in the range of about 650°C. to about 850°C. for about five to thirty seconds.’ (Col. 4, lines 11-15).

“Conversely, Emesh teaches that when ‘annealing at 650°C., it is known that Ti from the adhesion layer, and Pb from PZT, may diffuse into the Pt layer. . . [and] may cause an increase in the leakage current.” (Col. 2, lines 60-67). Further, that “a number of problems occur with integration of PZT and other ferroelectric materials into conventional process flows, many of these problems being related to the relatively high temperature which is required for processing.” (Col. 3, lines 8-14) (emphasis added). Thus, the annealing process in Emesh is carried out at 450°C for 300 seconds (Col. 5, lines 19-45).

“The Office Action asserts that Emesh teaches increasing the temperature at which the wet oxidation occurs increases the dielectric constant of the ferroelectric, and that this is support for the motivation to use higher temperatures than 500°C. However, Emesh specifically discloses that the focus of ‘this effort was a reduction of the crystallization temperature of the PZT from -650°C. to <500°C.’ (Col. 5, lines 52-54) (emphasis added). There is no motivation to use temperatures higher than

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500°C. Further, Patel teaches an anneal process at temperatures greater than 650°C. Thus, there is no motivation to combine Patel with Emesh.

Herein Applicant argues that because Patel is using a higher temperature than Emesh, one of ordinary skill would not be motivated to combine the references. Examiner respectfully disagrees. First, Emesh solves the *necessity* of higher temperature anneals normally required by *dry* oxygen/ozone anneal, such as the one used in Patel, by incorporating steam with the ozone and oxygen to carry out the anneal of the PZT layer. Accordingly, one of ordinary skill would be motivated to incorporate steam during the Patel annealing to reduce the *necessity* of higher temperature required to crystallize the PZT (ferroelectric) material, as taught in Emesh. (Compare in Emesh the section entitled "Background of the Invention" -- for example, paragraph bridging col. 1 and 2-- with the section entitled "Summary of the Invention" --for example at col. 3, lines 40-60 or col. 4, lines 4-16.) These passages support rather than teaches away from the combining of the references because Emesh recognizes the *potential* problem of, and provides a solution to the *necessity* of higher-temperature *dry*-oxygen/ozone annealing required to crystallize amorphous PZT films, encountered in Patel.

Note in particular that lower temperature annealing is not always required. Emesh states that in the event that *aluminum wiring* (or low melting alloy) has already been deposited, lower temperature anneals may be required to prevent melting of said wiring (col. 2, lines 20-31; col. 4, lines 31-36). But because water (as steam), in and of itself, reduces the stress in the films, one of ordinary skill would still be motivated to incorporate steam simply to reduce the stress (Emesh col. 5, lines 50-67). Lower temperatures would not be necessary if low melting wiring had not already been deposited. Since Patel uses Pt or Ti as the electrodes (col. 3, lines 21-28)--which

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have melting points of 2045 °C and 1943 °C, respectively-- there is absolutely no requirement for Patel to anneal at lower temperatures, as one of ordinary skill would clearly recognize based upon the melting point of the materials already deposited during fabrication which are high-melting materials. Clearly neither Patel nor one of ordinary skill would use a temperature so high that it would damage the very device being fabricated --and there exists no need to use lower temperatures to still gain the benefit of reduced film stress taught in Emesh.

Moreover, as noted in the rejection above, since Emesh teaches that higher temperature anneals increases that dielectric constant of the PZT over lower temperature anneals, one of ordinary skill would still be motivated to use the higher temperatures if the materials (e.g. the metal wiring) could withstand the temperature, in order to gain beneficially higher dielectric constant. (See Emesh, column 8, lines 6-12). Accordingly, *Emesh supports higher temperature anneals* to gain higher dielectric constants of the ferroelectric materials and accordingly does not teach away from the anneal temperatures in Patel.

Finally, it is noted the each of Applicant's independent claims only require temperatures greater than 450 °C, which is anticipated by Patel and Emesh.

Applicant continues,

"Further, Emesh teaches that "annealing in higher ozone concentrations may be impractical for semiconductor processing, in view of safety concerns regarding toxicity and potential fire hazard of ozone at higher concentrations (>30% ozone), and the requirement that any unreacted ozone is destroyed before exhausting the annealing chamber to atmosphere" (Col. 6, lines 9-15). Whereas, Patel teaches a "first anneal in an ozone atmosphere using a rapid thermal anneal process." (Col. 3, lines 64-65). Emesh discloses that the anneal should only have a 'few percent of ozone' (Abstract). This is an additional reason that these two references are not combinable."

"Applicants also respectfully submit that the cited references, Patel and Chivukula, are not combinable as the Office Action asserts. Chivukula



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teaches using a 'sol-gel precursor solution . . . using rapid thermal annealing at relatively low temperatures.' (Col. 8, lines 22-25). In fact, the ferroelectric layer is 'annealed by a rapid thermal annealing (RTA) process at above 450°C., and up to 650°C.' (Col. 13, lines 36-40) (emphasis added). 'The combined effect of oxygen/ozone in the presence of water vapour was found to reduce significantly the temperature and time required for crystallization to occur, i.e., from above 650°C . . . to about 450°C.' (Col. 14, lines 34-38). Conversely, Patel teaches that the "ozone molecule decomposes into an oxygen atom and oxygen molecule in a few milliseconds at 500°C. or above." (Col. 2, lines 25-27).

Herein Applicant argues that because Patel is using primarily ozone, one of ordinary skill would not use the lower ozone concentrations of Emesh. Examiner respectfully disagrees. First, there is no teaching that Patel is using "primarily ozone" as alleged by Applicant. Patel states, "This first anneal can be conducted using either a single anneal or a combination of anneals. The anneal can be done using a RTA or furnace anneal with O<sub>2</sub> **and/or** O<sub>3</sub> gas at a pressure over the Curie temperature of the ferroelectric material" (col. 4, lines 23-27; emphasis added). Accordingly, the mixture of oxygen and ozone is taught.

Further in this regard, Applicant clearly recognizes --as stated in the last sentence of the excerpt from Applicant's Response just cited-- that Patel notes that ozone decomposes at temperatures over 500 °C. Accordingly, Applicant's argument that Patel uses primarily ozone directly contradicts that fact that there will be no ozone within a few milliseconds, since the temperatures used in Patel are higher than 500 °C. Accordingly, there is no ozone fire hazard since there will be no ozone as Applicant alleges based upon Emesh --were Patel using "primarily ozone." Moreover, Patel says that the

Applicant continues in this regard,

"Accordingly, Patel benefits from using higher temperatures since ozone molecules will disassociate quickly; thus, increasing the diffusion of

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oxygen into the ferroelectric crystal and reducing the number of lead atoms that are lost, e.g., above 650°C, utilizing an ambient atmosphere primarily comprising ozone. Whereas, both Emesh and Chivukula are directed to low temperature anneals, e.g., below 650°C, in atmospheres with a very low percentage of ozone present. There is simply no suggestion or teaching that the methods of Emesh and Chivukula will work in an ambient atmosphere comprising primarily ozone, much less only ozone. Further, as is known in the art, utilizing bubbler systems requires the bubbler system to be opened to the atmosphere periodically to replenish the water. Even if the cited references were combinable as asserted, which they are not, the unreacted ozone of Patel would need to be first purged prior to adding water to the bubbler system. In contrast, both Chivukula and Emesh teach the addition of only a small percentage of ozone to the ambient atmosphere used in the annealing process.

First, as already noted, Patel does not require the use of pure ozone. Second, Patel teaches that “ozone quickly decays to  $O_2$  and  $O^-$  at temperatures greater than 400 °C (col. 2, lines 11-17; emphasis added). Accordingly, given the exemplary annealing temperatures in each of Emesh and Chivukula, (e.g. greater than 400 °C) the atmosphere during annealing would be primarily  $O_2$  because  $O^-$  is extremely reactive (second only to atomic fluorine, given their electronegativities) and would either react with some material with which it came in contact (such as the ferroelectric material or the chamber surface) or would react with other  $O^-$  to form  $O_2$ , as would be known to one of ordinary skill.

More importantly in this regard, nowhere do the references of any of Patel, Emesh, and Chivukula teach that some quantity of ozone would not work, high or low. Any alleged fire hazard or purge requirement with effluent gases is moot since the ozone decomposes at the anneal temperatures used in each reference. A point admittedly recognized by Applicant and noted in Patel. Patel further does not require primarily ozone as alleged by Applicant. Moreover, the ozone is decomposed at least “quickly” at the anneal temperatures used in each of the applied

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references. Moreover, one of ordinary skill would clearly benefit from the ozone anneals in lower concentration given the incorporation of the teachings of either of Emesh or Chivukula.

NOTE that each of the references of Patel, Emesh, and Chivukula is discussing exactly the same material **PZT**, so there exists a more than reasonable expectation of success of applying the annealing methods of either of Emesh and Chivukula with Patel.

As noted in the two excerpts from Applicant's Response, Applicant argues that Chivukula teaches relatively low temperature anneals and ozone concentrations to Patel. Examiner respectfully disagrees. Applicant may have missed the teaching in Chivukula, which states that temperatures of 600 °C to 800 °C may be used if compatible with other process steps (Chivukula col. 12, lines 32-38). This runs in direct contradiction to Applicant's assertion that Chivukula only anneals at temperatures up to 650 °C. Chivukula also recognizes that ozone speeds up the oxidation. Moreover, Patel indicates no ozone concentrations. Accordingly, these reasons are not convincing as to teaching away from Patel.

Regarding the combination of the basic text of Van Zant as a showing of the well-known and preferred use of in-situ steam generation with Patel in view of either of Emesh and Chivukula, Applicant argues,

"The Office Action further relies on Van Zant for the proposition that Dryox rectifies the deficiencies associated with Emesh and Chivukula. Primarily, that Van Zant teaches using a mixture of hydrogen and oxygen to form steam rather than liquid systems such as a bubbler. However, Van Zant teaches that 'under the influence of the high temperature,' steam is formed (15' para., page 160). Chivukula and Emesh are directed to low temperature anneals.

"In addition, Van Zant teaches that '[b]ubblers . . . are adequate . . . [but] [1]liquid-water-steam systems are unreliable for growing thin, clean gate oxides." (Pages 159-160). Further, a drawback to dryox system is the "explosive property of hydrogen.' (Page 160). Accordingly, excess oxygen is flowed into the tubes to ensure that every hydrogen molecule will

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combine with an oxygen atom to form water (Page 160). Each of the cited references use ozone which already poses a potentially hazardous problem, particularly in Patel. Van Zant specifically discloses that at 'oxidation temperatures, hydrogen is very explosive.' (page 160). There is no motivation to use the teachings of Van Zant with Emesh or Chivukula since the bubblers employed are adequate. Notwithstanding that neither of the cited references, Patel, Emesh, or Chivukula, discuss formation of a gate structure utilizing their methods. The dryox method is the preferred method only when talking about gate structures, even then, it is only a preferred method and not the only method.

In this regard, the previous Office action states,

"**Van Zant** teaches that 'Dryox,' a mixture of hydrogen and oxygen which react to form a steam oxidizing mixture in the reactor, is preferred over liquid systems such as a bubbler, because the process is cleaner and more controllable and also that 'Dryox' is the preferred method for production of **advanced devices**." (See pp. 157-160 -- especially page 160.) (Emphasis added.)

"It would have been obvious to one of ordinary skill in the art at the time the invention was made to use hydrogen and oxygen as taught by **Van Zant** to form the steam for the wet oxidation mixture of either of **Emesh** and **Chivukula**, for the reasons indicated in **Van Zant**, as noted and especially because 'Dryox' is preferred to bubblers which **Emesh** and **Chivukula** use.

This provides express suggestion to use Dryox as the method of forming steam for any "advanced device." Nowhere does Van Zant indicate that Dryox is only for gate oxides as alleged by Applicant. One of ordinary skill would be especially motivated to use Dryox to gain the control of steam concentration relative to the other gases and the cleanliness of the process as taught in Van Zant. Also no temperature range is taught in Van Zant, as the Dryox is a generalized method of forming steam for annealing. Accordingly, it would be improper to make the assertion that the temperatures ranges are somehow different, since none have been indicated in Van Zant.

Examiner notes with interest, that each of the limitations which Applicant indicates that one other reference is teaching may be potential safety hazards, is nonetheless each being employed in the instant invention. Any such safety hazard would clearly be encountered by Applicant him/herself. Semiconductor manufacturing is replete with safety hazards, as is most industrial manufacture involving toxic chemicals. Nonetheless, hazardous materials are used in the semiconductor industry everyday without catastrophic results. A potential safety hazard simply is not a teaching away in light of the benefits resulting from the methods.

Moreover, Examiner respectfully asserts that in indication that something is "adequate" would somehow lead one of ordinary skill to ignore the benefits of better methods of doing the same. Accordingly, that the bubbler may be adequate would not deter one of ordinary skill from using new and improved or preferred methods of forming steam for annealing, such as that in Van Zant.

The remainder of Applicant's arguments regarding claims 42, 43, and 44 are based upon the alleged failure of Ohmi or Ghandi to make up the deficiencies in Patel in view of either of Emesh and Chivukula. Examiner respectfully asserts that, based upon the record, Patel in view of either of Emesh and Chivukula is not deficient and that Ohmi and Ghandi are properly combinable with the other references for reasons already indicated, as noted above in the rejections. For brevity, said reasons for combining are herein incorporated by reference.

Examiner also acknowledges each of Applicant's arguments that the new limitation that that the "steam is provided in a ratio of at least 0.005 relative to the other gases present in the rapid thermal process chamber" is not taught is moot in view of the new ground of rejection necessitated by this amendment.

*Conclusion*

7. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Erik Kielin whose telephone number is 703-306-5980. The examiner can normally be reached on 9:00 - 19:30 on Monday through Thursday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead, Jr., can be reached at 703-308-4940. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9318 for regular communications and 703-872-9319 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Erik Kielin  
January 31, 2003

  
ERIK KIELIN  
PATENT EXAMINER